RIETI Discussion Paper Series 10-E-040

Productivity, Markup, Scale Economies, and the Business Cycle: Estimates from firm-level panel data in Japan

KIYOTA Kozo
Yokohama National University

Research Institute of Economy, Trade & Industry, IAA
The Research Institute of Economy, Trade and Industry
http://www.rieti.go.jp/en/

RIETI Discussion Paper Series 10-E-040
July 2010

Productivity, Markup, Scale Economies, and the Business Cycle: Estimates from firm-level panel data in Japan*

Kozo KIYOTA†
Faculty of Business Administration, Yokohama National University

Abstract

This paper examines the relationship between productivity, markup, scale economies, and the business cycle. The paper contributes to the literature by presenting a simple econometric framework that permits simultaneous estimation of the changes in productivity, markup, and scale economies from a panel of firm-level data. The framework is then applied to Japanese firm-level data for 1994 - 2006. The results indicate that productivity is procyclical even after the changes in markup and scale economies are controlled for. However, both markup and scale economies are neither procyclical nor countercyclical once the changes in productivity are taken into account.

Key words: Productivity, Markup, Scale Economies, Business Cycle, Japan
JEL classification: D24, O4, E32, L16

*The research in this paper was conducted at the Research Institute of Economy, Trade and Industry (RIETI). Thanks to Mitsuhiro Fukao and seminar participants at Keio University, Japan Center for Economic Research (JCER), and RIETI for their helpful comments on earlier versions of this paper. I am grateful to Toshiyuki Matsuura for help with accessing some of the data. Financial support from the Japan Society for the Promotion of Science (Grant-in-aid A-22243023) is acknowledged gratefully. All errors or omissions are the sole responsibility of the author.
†Faculty of Business Administration, Yokohama National University, 79-4 Tokiwadai, Hodogaya-ku, Yokohama 240-8501, Japan; Phone: +81-45-339-3770; Fax: +81-45-339-3707; E-mail: kiyota[at]ynu.ac.jp

1 Introduction

This paper examines the relationship between productivity, markup, scale economies, and the business cycle, which is one of the central concerns in various fields of economics.[1] Our motivation comes from two strands of research. One is the literature on the relationship between productivity and the business cycle. As Basu and Fernald (2001) have argued, the procyclical movement of productivity is closely related to the impulses underlying the business cycle. Accordingly, several studies have asked whether productivity is procyclical or countercyclical. Many of them have found procyclical movement in the United States (Basu, 1996), Japan (Miyagawa, Sakuragawa, and Takizawa, 2006), and Europe (Inklaar, 2007).

The other strand is the study of the relationship between markup and the business cycle. Changes in markup provide us with important information about the changes in market structure. Furthermore, the changes in markup over the business cycle can significantly affect the inflation dynamics of the economy. Previous studies have presented mixed results. Using industry-level data, Rotemberg and Woodford (1991) and Chevalier and Scharfstein (1996) found that markup was countercyclical in the United States. In contrast, Beccarello (1995) found procyclical movement of markup for major OECD countries except for the United States, using industry-level data. Nishimura, Ohkusa, and Ariga (1999) and Kiyota, Nakajima, and Nishimura (2009) further extended the analysis, utilizing firm-level data in Japan. Both of these studies found procyclical movement of markup.

Both strands of research have made significant contributions to the literature. However, the first strand of studies ignored the cyclical movement of markup, and the second strand ignored the cyclical movement of productivity. These studies thus could not distinguish

[1] In this paper, productivity means total factor productivity (TFP). Markup is measured by price over marginal cost. The business cycle is defined as the changes in real value added at the industry and aggregate levels.

between the cyclical movement of markup and that of productivity. This in turn implies that the estimated markup and/or productivity could be over- or underestimated.

This paper proposes a framework to integrate these two strands of study. The following two questions are addressed in this paper: 1) Do sectoral productivity, markup, and scale economies correlate with the business cycle? 2) Is aggregate productivity procyclical? A contribution of this paper is to present a simple econometric framework that permits *simultaneous* estimation of the changes in productivity, markup, and scale economies. In other words, this paper estimates productivity growth, controlling for the changes in markup and scale economies at the same time. Our empirical work relies primarily on the tools developed by Klette (1999) together with the idea of a productivity chain index developed by Good, Nadiri, and Sickles (1997). The framework is then applied to Japanese firm-level data between 1994 and 2006, covering more than 8,000 manufacturing firms annually. Based on the markup corrected measures developed by Basu and Fernald (2001), the estimated sectoral productivity growth is aggregated to obtain some macroeconomic implications.

This paper also contributes to the recent discussion on the productivity growth of the Japanese economy. Since Hayashi and Prescott (2002) argued that the decline in productivity was a major factor in the prolonged recession of the Japanese economy in the 1990s, several studies have examined the relationship between productivity dynamics and the business cycle in Japan. Miyagawa, Sakuragawa, and Takizawa (2006) used quarterly industry-level data for 1976–2002 and found procyclical movement of productivity. Kawamoto (2005) used annual industry-level data for 1973–1998 and made various adjustments for TFP to remove the effects of factors other than technology change. He found that TFP did not decline in the 1990s. These studies contribute to a deeper understanding of the current Japanese economy. However, these studies pay little attention to changes in markup and, therefore, their productivity estimates could be biased severely.[2]

The next section presents the methodology. Section 3 explains the data used in this paper. The estimation results are presented in Section 4. Section 5 provides a summary and concluding remarks.

2 Methodology

2.1 Production function

The model relies primarily on the tools developed by Klette (1999) together with the idea of the productivity chain index by Good et al. (1997). Firm i in industry n is assumed to produce output Y using capital X^K, labor X^L, and intermediate inputs X^M in year t, with a production function $Y_{it} = A_{it}F_t(X_{it}^K, X_{it}^L, X_{it}^M)$, where A_{it} is a firm-specific productivity factor.[3] Assume that the firm has some market power in the output market whereas it is a price taker in the input markets. Rewrite the production function in terms of logarithmic deviations from the representative reference firm r in the *initial* year (i.e., $t = 0$):[4]

$$y_{it} = a_{it} + \tilde{\alpha}_{it}^K x_{it}^K + \tilde{\alpha}_{it}^L x_{it}^L + \tilde{\alpha}_{it}^M x_{it}^M , \tag{1}$$

where lowercase letters denote the logarithmic deviation from the reference firm of the corresponding upper case variable. For example, $y_{it} = \ln(Y_{it}) - \ln(Y_{r0})$; $\tilde{\alpha}_{it}^j$ are the output

[2]Both Kawamoto (2005) and Miyagawa et al. (2006) assumed constant markup.

[3]In Sections 2.1 and 2.2, we omit subscript n identifying the industry to avoid confusion from the notation.

[4]The representative reference firm is the firm that has the arithmetic mean values of log output and log inputs over firms in the initial year. This approach follows the chain index of the hypothetical firm in Good et al. (1997).

elasticities for input $j \in (K, L, M)$ evaluated at $\tilde{X}^j_{it}$:

$$\tilde{\alpha}^j_{it} = \left[\frac{X^j_{it}}{Y_{it}} \frac{\partial Y_{it}}{\partial X^j_{it}} \right]_{X^j_{it} = \tilde{X}^j_{it}}, \tag{2}$$

where $\tilde{X}^j_{it}$ is an internal point between the input of firm i and that of the reference firm. Denote the price of output, capital, labor, and intermediate inputs for firm i in year t as p_{it}, p^K_{it}, p^L_{it}, and p^M_{it}, respectively.

The firm's optimization problem is assumed to maximize profits. The first-order conditions imply that:

$$\frac{\partial Y_{it}}{\partial X^j_{it}} = A_{it} \frac{\partial F_t(\cdot)}{\partial X^j_{it}} = \frac{p^j_{it}}{(1 - \epsilon^{-1}_{it}) p_{it}}, \tag{3}$$

where ϵ_{it} is the price elasticity of demand (i.e., $\epsilon_{it} = -(dY_{it}/Y_{it})/(dp_{it}/p_{it})$). Let s^j_{it} and s^j_{r0} be firm i's cost share of input j relative to total revenue in year t and the reference firm's cost share in the initial year, respectively.[5] Because $(1 - \epsilon^{-1}_{it})^{-1}$ represents the ratio of price to marginal cost, or markup μ_{it}, we have:

$$\tilde{\alpha}^j_{it} = \mu_{it} \tilde{s}^j_{it}, \tag{4}$$

where $\tilde{s}^j_{it} = (s^j_{it} + s^j_{r0})/2$. Define the elasticity of scale in production as:

$$\eta_{it} = \sum_j \tilde{\alpha}^j_{it}. \tag{5}$$

Klette (1999) argued that equation (4) does not necessarily hold for capital because of various capital rigidities (e.g., quasi-fixity of capital stock). Following Klette (1999), this

[5]The reference firm's cost share is defined as the arithmetic mean of the cost share over all firms.

paper handles this problem as follows. From equation (5):

$$\tilde{\alpha}_{it}^{K} = \eta_{it} - \mu_{it}(\tilde{s}_{it}^{L} + \tilde{s}_{it}^{M}). \tag{6}$$

Equation (1) is rewritten as:

$$y_{it} = a_{it} + \mu_{it} x_{it}^{V} + \eta_{it} x_{it}^{K}, \tag{7}$$

where

$$x_{it}^{V} = \sum_{j \neq K} \tilde{s}_{it}^{j}(x_{it}^{j} - x_{it}^{K}). \tag{8}$$

Note that, under perfect competition in the output market (i.e., $\mu_{it} = 1$) and constant returns to scale technology (i.e., $\eta_{it} = 1$), equation (1) is written as:

$$y_{it} = a_{it} + \sum_{j} \tilde{s}_{it}^{j} x_{it}^{j}. \tag{9}$$

Therefore,

$$\begin{aligned} a_{it} &= \ln A_{it} - \ln A_{r0} \\ &\sim (\ln Y_{it} - \ln Y_{r0}) - \sum_{j} \frac{1}{2}(s_{it}^{j} + s_{r0}^{j})(\ln X_{it}^{j} - \ln X_{r0}^{j}) \\ &\sim (\ln Y_{it} - \ln Y_{rt}) - \sum_{j} \frac{1}{2}(s_{it}^{j} + s_{rt}^{j})(\ln X_{it}^{j} - \ln X_{rt}^{j}) \\ &\quad + (\ln Y_{rt} - \ln Y_{r0}) - \sum_{j} \frac{1}{2}(s_{rt}^{j} + s_{r0}^{j})(\ln X_{rt}^{j} - \ln X_{r0}^{j}), \end{aligned} \tag{10}$$

which corresponds (approximately) to the productivity chain index developed by Good et al. (1997).

One may be concerned with the following relationship between markup μ_{it} and scale economies η_{it}:

$$\eta_{it} = \frac{AC_{it}}{MC_{it}} = \frac{p_{it}}{MC_{it}} \frac{AC_{it}}{p_{it}} = \mu_{it} \left(\sum_j s_{it}^j \right) = \mu_{it}(1 - s_{it}^{\pi}), \tag{11}$$

where AC_{it} is average cost; MC_{it} is marginal cost; and s_{it}^{π} is the profit rate, which is defined as the share of economic profit in total (gross) revenue.[6] Equation (11) in turn implies that μ_{it} and η_{it} move in tandem. Note, however, that $\tilde{\alpha}_{it}^K \neq \mu_{it}\tilde{s}_{it}^K$ because of capital rigidities. Therefore, the third equality in equation (11) does not hold. This means that markup and scale economies can move differently when capital rigidities exist.

2.2 Estimation strategy

The first-difference version of equation (7) is:

$$\Delta y_{it} = \Delta a_{it} + \Delta\{\mu_{it} x_{it}^V\} + \Delta\{\eta_{it} x_{it}^K\}, \tag{12}$$

where Δ indicates the first-difference operator between years t and $t-1$. For example, $\Delta y_{it} = y_{it} - y_{it-1}$. Suppose that the term a_{it} consists of a firm-specific fixed effect and a random error term u_{it}: $a_{it} = a_i + a_t + u_{it}$;[7] the term μ_{it} consists of the firm-specific fixed effect μ_i and the time-specific industry-average effect μ_t: $\mu_{it} = \mu_i + \mu_t$;[8] and the term η_{it} consists of the firm-specific fixed effect η_i and the time-specific industry-average effect η_t:

[6] Under perfect competition in the output market, $p_{it} = AC_{it} = MC_{it}$. Therefore, $\eta_{it} = 1$ (i.e., constant returns to scale). For more details about this identity, see Basu and Fernald (1997).

[7] Like Klette (1999), the firm-specific fixed effect a_i disappears because of first differences. Unlike Klette (1999), however, the productivity change common across firms within an industry a_t cannot be neglected because all variables are measured relative to the reference firm in the *initial* year.

[8] A similar specification has been employed in Kiyota et al. (2009).

$\eta_{it} = \eta_i + \eta_t$. Equation (12) is rewritten as follows:

$$\begin{aligned} \Delta y_{it} &= \Delta a_t + \Delta\mu_{it}\bar{x}_{it}^V + \bar{\mu}_{it}\Delta x_{it}^V + \Delta\eta_{it}\bar{x}_{it}^K + \bar{\eta}_{it}\Delta x_{it}^K + \Delta u_{it} \\ &= \Delta a_t + \Delta\mu_t\bar{x}_{it}^V + \bar{\mu}_t\Delta x_{it}^V + \Delta\eta_t\bar{x}_{it}^K + \bar{\eta}_t\Delta x_{it}^K + \Delta v_{it}, \end{aligned} \tag{13}$$

where

$$\Delta v_{it} = \Delta u_{it} + \bar{\mu}_i\Delta x_{it}^V + \bar{\eta}_i\Delta x_{it}^K. \tag{14}$$

An upper bar indicates the average between years t and $t-1$. For example, $\bar{x}_{it}^V = (x_{it}^V + x_{it-1}^V)/2$. Similar to Klette (1999), the averages of industry markup $\bar{\mu}_t$ and scale economies $\bar{\eta}_t$ between years t and $t-1$ are estimated. Furthermore, this framework allows us to estimate *simultaneously* the changes in productivity Δa_t, markup $\Delta\mu_t$, and scale economies $\Delta\eta_t$.

Note that equation (13) cannot be consistently estimated by OLS because random productivity shocks might be correlated with changes in factor inputs to the extent that the shocks are anticipated before factor demands are determined. In addition, there might be possible reporting errors in variables. The model is estimated using orthogonality assumptions between error term Δv_{it} and a set of instruments $\mathbf{Z}_{it}$:

$$E(\mathbf{Z}_{it}'\Delta v_{it}) = 0. \tag{15}$$

The parameters to be estimated are $\bar{\mu}_t$, $\bar{\eta}_t$, Δa_t, $\Delta\mu_t$, and $\Delta\eta_t$ in equation (13). One-step system GMM (Blundell and Bond, 1998) is employed for the estimation.[9] Two types of instruments are used to check the robustness of the results. One is lagged differences of

[9]We employ system GMM although Klette (1999) employed Arellano and Bond GMM (Arellano and Bond, 1991) because system GMM overcomes several problems of Arellano and Bond GMM such as initial conditions problems. Van Biesebroeck (2007) has found that system GMM provided the most robust productivity growth estimates of the parametric methods when measurement error or heterogeneous production technology exists. For more details about system GMM, see Baltagi (2005, pp. 147–148).

the year dummies, $\bar{x}_{it}^{K}$, and Δx_{it}^{K} as instruments for equations in levels, in addition to lagged level values of the year dummies, $\bar{x}_{it}^{K}$, and Δx_{it}^{K} as instruments for equations in first differences (Instruments I). This means that productivity shocks and capital stock are exogenous while labor and intermediate inputs are endogenous. The other excludes $\bar{x}_{it}^{K}$ from Instruments I (Instruments II). This means that productivity shocks are exogenous while other inputs are endogenous. Whether equation (15) holds is examined by the Hansen test statistics.

3 Data

We use the confidential micro database of the *Kigyou Katsudou Kihon Chousa Houkokusho* (*Basic Survey of Japanese Business Structure and Activities*: *BSJBSA*) prepared annually by the Research and Statistics Department, METI (1994–2006). This survey was first conducted in 1991, and then annually from 1994. The main purpose of the survey is to capture statistically the overall picture of Japanese corporate firms in light of their activity diversification, globalization, and strategies on research and development and information technology.

The strength of the survey is its sample coverage and reliability of information. The survey is compulsory for firms with more than 50 employees and with capital of more than 30 million yen in manufacturing and nonmanufacturing firms (some nonmanufacturing sectors such as finance, insurance, and software services are not included). The limitation of the survey is that some information on financial and institutional features such as *keiretsu* are not available, and small firms with fewer than 50 workers (or with capital of less than 30 million yen) are excluded.[10]

From the *BSJBSA*, we constructed a longitudinal (panel) data set from 1994 to 2006

[10]In 2002, the *BSJBSA* covered about one-third of Japan's total labor force excluding the public, financial, and other services sectors that are not covered in the survey (Kiyota et al. 2009).

in order to estimate equation (13). Output Y_{it} is defined as real gross output measured by nominal sales divided by the sectoral gross output price deflator p_t. Inputs consist of labor, capital, and intermediate inputs. Labor X_{it}^L is defined as man-hours. Real capital stock X_{it}^K is computed from tangible assets and investment based on the perpetual inventory method. Intermediate inputs X_{it}^M are real intermediate inputs and are defined as nominal intermediate inputs deflated by the sectoral input price deflator p_t^M. The working hours and price deflators are not available in the *BSJBSA* and are obtained from the Japan Industrial Productivity (JIP) 2009 database, which was compiled as a part of a research project by the Research Institute of Economy, Trade, and Industry (RIETI) and Hitotsubashi University.[11]

We focus on manufacturing to enable a comparison with the results of previous studies. We remove firms from our sample for which sales and inputs are not positive. We also remove firms whose changes in output and inputs exceed mean$\pm 4\sigma$, where σ is the standard deviation of the corresponding variable. Reentry firms that disappeared once and reappeared are also removed because it is difficult to construct the capital stock in a consistent way. The number of observations exceeds 8,000 annually.[12] A more detailed explanation about the variables is provided in Data Appendix.

Table 1 presents the average growth of output, by industry. The output is measured by real value added. Two findings stand out from this table. First, the large negative growth of real value added is confirmed for 1997–1998 when the Asian financial crisis hit the Japanese economy and for 2000–2001 when the information technology bubble burst. The average growth rate of manufacturing output was -15.7 percent and -6.8 percent for 1997–1998 and 2002–2003, respectively. Second, the growth of output differs across industries. The annual average growth rate of manufacturing was 7.0 percent between 1994 and 2006. However, the annual average growth of clothing was -4.2 percent whereas

[11]The concordance of the industry classification between the *BSJBSA* and JIP 2009 database is presented in Table A1. For more details about the JIP database, see Fukao et al. (2007).
[12]Table A2 presents the number of firms, by industry.

that of electronic parts and components was 15.4 percent. These results together suggest that the growth of output is heterogeneous across years and across industries.

=== Table 1 ===

4 Productivity, Markup, Scale Economies, and the Business Cycle

4.1 Do sectoral productivity, markup, and scale economies correlate with the business cycle?

Given that we estimate more than 3,000 parameters, it is impossible to report all of the results here. However, it is possible to provide some summary and test statistics that can shed light on the plausibility of the estimates. Table 2 presents some test statistics as well as period-average markup (i.e., $\hat{\bar{\mu}}_{nt}/12$) and scale economies (i.e., $\hat{\bar{\eta}}_{nt}/12$).

=== Table 2 ===

Two findings stand out from this table. First, the test statistics indicate that the regression performs well in general. The Hansen test statistics indicate that the exogeneity of instruments is not rejected in almost all industries. This implies that the choice of instruments has some validity. The presence of significant first order autocorrelation is expected because the model is estimated in first differences. The presence of significant second order autocorrelation is not confirmed in almost all industries.

Second, the industry-average markup and scale economies are comparable to those of previous studies. In Instruments I, the estimated period-average markups of 26 industries range from 0.825 to 1.104. In Klette (1999), the estimated markups of 14 industries range from 0.649 to 1.088. Similarly, the estimated period-average scale economies range from

0.782 to 1.012, while those of Klette (1999) range from 0.653 to 1.009. Quantitatively similar results are obtained when we use Instruments II. These results show the plausibility of the estimates.

Is markup constant? As we discuss in the next section, this question is particularly important in aggregating industry-level productivity growth. To answer this question, we test the null hypothesis $H_0 : \Delta\hat{\mu}_{1995} = ... = \Delta\hat{\mu}_{2006} = 0$, by industry. If markup is constant, the null hypothesis will not be rejected. We also test the null hypothesis $H_0 : \Delta\hat{\eta}_{1995} = ... = \Delta\hat{\eta}_{2006} = 0$ (i.e., no change in scale economies) and $H_0 : \Delta\hat{a}_{1995} = ... = \Delta\hat{a}_{2006} = 0$ (i.e., no productivity growth) to check the plausibility of the estimates.

Test statistics are presented in Table 3. Major findings are threefold. First, markup is not necessarily constant throughout the period. For Instruments I, 18 out of 26 industries reject the null hypothesis of constant markup. For Instruments II, 14 industries reject the null hypothesis. These results mean that markup shows significant changes in more than half of industries. Second, similarly, scale economies are not necessarily constant over the period. The null hypothesis is rejected in 15 industries for both Instruments I and II. Finally, the model captures the productivity shocks well. All industries reject the null hypothesis for both Instruments I and II.

=== Table 3 ===

One may argue that the null hypothesis $H_0 : \hat{\hat{\mu}}_t = 1$ (i.e., no market power) is not necessarily rejected even though markup is not constant. As we argue in the next section, if the null hypothesis $H_0 : \hat{\hat{\mu}}_t = 1$ is not rejected, we can employ the Dormar weighted measures in aggregating industry-level productivity growth. Table 3 tests the null hypothesis $H_0 : \hat{\hat{\mu}}_{1995} = ... = \hat{\hat{\mu}}_{2006} = 1$ to answer this question. We also test the null hypothesis $H_0 : \hat{\hat{\eta}}_{1995} = ... = \hat{\hat{\eta}}_{2006} = 1$, by industry, to examine the existence of scale economies.

The results indicate that the hypothesis $H_0 : \hat{\hat{\mu}}_{1995} = ... = \hat{\hat{\mu}}_{2006} = 1$ is not supported in the majority of industries. For Instruments I, the null hypothesis is rejected in 22 out of 26 industries. Similarly, Table 3 does not support constant returns to scale. For Instruments I, the null hypothesis $H_0 : \hat{\hat{\eta}}_{1995} = ... = \hat{\hat{\eta}}_{2006} = 1$ is rejected in 23 out of 26 industries. Quantitatively similar results are obtained for Instruments II.

Do sectoral productivity, markup, and scale economies correlate with the business cycle? One might be concerned that productivity, markup, and scale economies can be affected by other factors such as external demand shocks. As control variables, we include the changes in exports ΔEXP_{nt}, those in the Herfindahl–Hirschman Index (HHI) ΔHHI_{nt}, and industry-specific effects β_n in order to control for the effects of external demand shocks and unobserved industry heterogeneity, respectively.[13] The regression equation is described as:

$$\Delta Z_{nt} = \beta_n + \gamma \Delta y_{nt}^{VA} + \lambda_1 \Delta EXP_{nt} + \lambda_2 \Delta HHI_{nt} + \epsilon_{nt}, \tag{16}$$

where ΔZ_{nt} denotes the changes in estimated productivity $\Delta \hat{a}_{nt}$, markup $\Delta \hat{\mu}_{nt}$, or scale economies $\Delta \hat{\eta}_{nt}$; Δy_{nt}^{VA} is the change in output in industry n between years $t-1$ and t. Output is defined as the sum of the real value added of firms in industry n (Table 1). To check the robustness of the results, ΔEXP_{nt} is measured by the growth of exports or the changes in the export–sales ratio. The data on exports and sales are obtained from the *BSJBSA*. The HHI is constructed from the sales share: $HHI_{nt} = \sum_i q_{int}^2$, where q_i is the market share of firm i in industry n in year t. The parameter of interest is γ, which shows the correlation with the sectoral business cycle. Industry-specific effects are captured by β_n. Note that the regression analysis does not necessarily examine causality. In other words, the analysis examines simply the correlation with the business cycle, controlling for other factors such as the changes in external demand.

[13] Year-specific effects can be captured by the constant term because all variables are measured in first differences.

=== Table 4 ===

Table 4 shows the regression results. The results indicate that the coefficients of the changes in output are significantly positive for the changes in productivity. The result suggests that the productivity growth is procyclical, which supports the finding of Miyagawa et al. (2006), who found procyclical movement of productivity in Japan. In contrast, the coefficients of the changes in output are insignificant for the changes in markup. This finding suggests that markup is neither procyclical nor countercyclical. This result contradicts the findings of Nishimura et al. (1999) and Kiyota et al. (2009), who found procyclical movement of markup in Japan. The relationship between scale economies and the business cycle is also insignificant.

The procyclical movement of productivity is confirmed even after changes in each variable are controlled for. However, the procyclical movement of markup disappears once the changes in productivity are taken into account. The results imply that previous studies may thus misinterpret the movement of procyclical productivity as procyclical markup.

The changes in exports are generally insignificant. Besides, this result holds whether the changes in exports are measured by the growth of exports or the changes in the export–sales ratio. This result suggests that the effects of external demand on productivity, markup, and scale economies may be limited in this period. The changes in HHI have significantly negative coefficients for productivity growth. This result means that productivity growth declines with increases in the industry's concentration. In other words, productivity growth is enhanced in competitive markets. In contrast, the changes in HHI do not show any significant coefficients for markup. Further analysis is needed to clarify the determinants of changes in markup.

4.2 Is aggregate productivity procyclical?

Is aggregate productivity procyclical? The estimation results in the previous section are not able to answer this question directly because productivity growth is estimated at the industry level. Note also that the previous section focuses on industry-average productivity growth. If productivity growth is different between large and small industries, the growth of aggregate productivity can show a different pattern from that of industry-average productivity. To aggregate the sectoral productivity growth, this paper utilizes the markup corrected measures developed by Basu and Fernald (2001).

Denote changes in aggregate productivity as Δa_t^A. Reintroduce industry subscript n. Define aggregate productivity growth Δa_t^A as a weighted average of industry productivity growth:

$$\Delta a_t^A = \sum_n \left(\frac{\bar{s}_{nt}^{VA}}{1 - \hat{\bar{\mu}}_{nt} \bar{s}_{nt}^M} \right) \Delta \hat{a}_{nt}, \tag{17}$$

where $\Delta \hat{a}_{nt}$ is the estimated productivity growth of industry n from equation (13); $\hat{\bar{\mu}}_{nt}$ is the estimated markup of industry n from equation (13); and $\bar{s}_{nt}^{VA}$ is the share of industry n's value added between years t and $t-1$:

$$\bar{s}_{nt}^{VA} = \frac{s_{nt}^{VA} + s_{nt-1}^{VA}}{2}, \quad \bar{s}_{nt}^{M} = \frac{s_{nt}^{M} + s_{nt-1}^{M}}{2}, \quad s_{nt}^{VA} = \frac{p_{nt} Y_{nt} - p_{nt}^M X_{nt}^M}{\sum_n (p_{nt} Y_{nt} - p_{nt}^M X_{nt}^M)},$$

$$p_{nt} Y_{nt} = \sum_{i \in n} p_{it} Y_{it}, \quad \text{and} \quad p_{nt}^M X_{nt}^M = \sum_{i \in n} p_{it}^M X_{it}^M. \tag{18}$$

The estimated industry productivity changes are first divided by $1 - \hat{\bar{\mu}}_{nt} \bar{s}_{nt}^M$ in order to convert them from a gross output to a value-added basis. These changes are weighted by the industry's share of aggregate value added.[14]

Note that this aggregation scheme does not include the contribution of entry and exit because growth is defined for firms that exist between years t and $t-1$. However, Nishimura

[14] Under perfect competition, $\hat{\bar{\mu}}_{nt} = 1$. This is known as the Domar weighted measure (Domar, 1961).

et al. (2005) used the same firm-level data for 1994–1998 and found that the effects of net entry (= entry − exit) on aggregate productivity growth were rather small. A similar finding is confirmed in Fukao and Kwon (2006). Although the effects of entry and exit could be substantial in other countries where entry and exit are active, they are marginal during the sample period in Japan.

For equation (17), a number of studies assumed that markup was constant over their sample period: $\hat{\hat{\mu}}_{nt} = \hat{\hat{\mu}}_n$, or that markup was equal to unity: $\hat{\hat{\mu}}_{nt} = 1$. However, the estimation results of the previous section questioned the empirical validity of these assumptions. The results suggest that one needs the parameters of markup by year and by industry in order to utilize the markup corrected measures. More careful treatment is thus needed in using the markup corrected measures. Unlike previous studies, the analysis in this paper takes into account the changes in markup.

Figure 1 presents the results. The business cycle is measured by the growth of real value added in manufacturing. Figure 1 indicates that aggregate productivity is procyclical. Indeed, the correlation coefficients between aggregate productivity and the business cycle are 0.90 for both Instruments I and II.[15] The results suggest that aggregate productivity is also procyclical even after the changes in markup and scale economies are controlled for.

=== Figure 1 ===

One may be concerned that the business cycle can be measured in alternative ways. For example, the Bank of Japan (BOJ) conducts a statistical survey called *TANKAN* (*the Short-term Economic Survey of Enterprises in Japan*) to capture the business trends of enterprises in Japan. Similarly, the METI surveys business conditions monthly and constructs the indices of industrial production and producers' shipments. These indices may be more appropriate for measuring the business cycle than changes in output.

[15] The correlation of aggregate productivity between Instruments I and II is 0.9986.

To address this concern, we also examine how the results are sensitive to the measurement of the business cycle. Three alternative measures are used in this paper: 1) *TANKAN*, 2) index of industrial production, or production index (PI), and 3) index of producers' shipments, or shipments index (SI). The *TANKAN* is obtained from the Bank of Japan (2010) while both PI and SI are obtained from METI (2010).[16] Note that the *TANKAN* is surveyed quarterly and the PI and SI are surveyed monthly. For the *TANKAN*, we first calculate the annual average indices (fiscal year basis) and then take the first differences between two consecutive years to compare with annual growth of aggregate productivity.[17]

Figure 2 presents the results. The results indicate that the procyclical movement of aggregate productivity is confirmed even when we utilize the different measures of the business cycle. The correlation coefficients between aggregate productivity and the *TANKAN* are 0.87 and 0.88 for Instruments I and II, respectively. Similarly, the correlation coefficients between aggregate productivity and PI are 0.86 and 0.87 for Instruments I and II, respectively, while those between aggregate productivity and SI are 0.84 and 0.85 for Instruments I and II, respectively. These results together suggest that the procyclicality of productivity is not sensitive to the measurement of the business cycle.

=== Figure 2 ===

5 Concluding Remarks

This paper asked two questions: 1) Do sectoral productivity, markup, and scale economies correlate with the business cycle? 2) Is aggregate productivity procyclical? A contribution of this paper is to present a simple econometric framework that permits *simultaneous* estimation of the changes in productivity, markup, and scale economies from a panel of firm-level data. The framework is then applied to Japanese firm-level data for 1994–2006.

[16]Both PI and SI are seasonally adjusted indices.

[17]We calculate the first difference rather than the growth rate because these indices take negative values.

The major findings of this paper are threefold. First, markup is not necessarily constant over the period. The null hypothesis that markup is constant is rejected in more than half of industries. The result implies that more careful treatment is needed in using the markup corrected measures to aggregate productivity growth because previous studies have assumed that markup is constant over the period.

Second, productivity shows procyclical movement. The relationship between sectoral value-added growth and sectoral productivity growth is significantly positive. At the aggregate level, the correlation coefficient between productivity and the business cycle, measured by aggregate real value added, is around 0.9. These results together imply that productivity is procyclical even after the changes in markup and scale economies are controlled for.

Third, however, markup and scale economies are neither procyclical nor countercyclical once changes in productivity are taken into account. At the sectoral level, the correlation between markup and the business cycle as well as the correlation between scale economies and the business cycle are insignificant. Insignificant correlation between markup and the business cycle contradicts the findings of Nishimura et al. (1999) and Kiyota et al. (2009), who found procyclical movement of markup in Japan. Previous studies thus may misinterpret the movement of procyclical productivity as procyclical markup.

The results of this paper also shed light on the importance of studies that utilize firm-level data in both industry- and aggregate-level analysis. A study utilizing industry-level data may not be able to estimate markup or scale economies by year and by industry because the number of parameters will exceed the number of observations. To clarify the relationship between productivity and the business cycle, therefore, it is imperative that the quality and coverage of the firm-level data be improved and expanded.

In conclusion, there are several research issues for the future that are worth mentioning. First, the analysis that utilized firm-level data in other countries is an important extension.

This paper found that the procyclical movement of markup disappears once the changes in productivity are controlled for. This result suggests that the observed procyclical movement of markup in other countries is likely to overstate the changes in markup.

Second, further investigation of the relationship between productivity, markup, and the business cycle is an important extension. For example, this paper utilized annual data. However, quarterly or monthly data might be more appropriate for capturing the business cycle. To conduct a more detailed analysis, more detailed firm-level data can be helpful.

Finally, it is also important to examine the determinants of changes in markup, productivity, and scale economies in more detail. A study using data on different countries and/or periods will add a national perspective to the growing body of empirical literature on productivity, markup, and the business cycle. Although this paper found procyclical movement of markup in Japan, different patterns may be confirmed in other countries. These issues will be addressed in our future research.

Data Appendix

Output is defined as total sales divided by the gross output price index. Total sales are available in the *Basic Survey of Japanese Business Structure and Activities* (*BSJBSA*). The gross output price index is obtained from the JIP 2009 database and defined as sectoral nominal gross output divided by sectoral real gross output (2000 constant prices).

Intermediate inputs are defined as nominal intermediate inputs divided by the input price index. Data for the nominal intermediate inputs are available in the *BSJBSA* and defined as: operating cost (= sales cost + administrative cost) − (wage payments + depreciation cost). The input price index is obtained from the JIP 2009 database and defined as sectoral nominal intermediate inputs divided by sectoral real intermediate inputs.

Labor input is defined as number of man-hours, which is each firm's total number of workers multiplied by working hours. The total number of regular workers is obtained from the *BSJBSA*. Because working hours are not available in the *BSJBSA*, we obtain sectoral annual average working hours from the JIP 2009 database and multiply it by the number of regular workers.

Capital stock is constructed from tangible fixed assets. In the *BSJBSA*, tangible fixed assets include land that is reported at nominal book values except for 1995 and 1996. In other words, the information on land is available only in 1995 and 1996. To construct capital stock, we first exclude land from tangible fixed assets, multiplying by (1 − land ratio):

$$\hat{B}_{it}^{K} = B_{it}^{K} \times (1 - \xi), \tag{A-1}$$

where $\hat{B}_{it}^{K}$ and B_{it}^{K} are the book value of tangible fixed assets that exclude land and include land, respectively, and ξ is the land ratio. For the land ratio, following Fukao and Kwon (2006), we use the industry-average ratio of land to tangible fixed assets in 1995 and 1996.[18]

The book value of tangible assets (excluding land) is then converted to the current value of, or nominal, tangible assets. The conversion rate is constructed from *Financial Statements Statistics of Corporations by Industry* published by the Ministry of Finance. The value of nominal tangible assets is then deflated by the investment goods deflator:

$$\hat{X}_{it}^{K} = \frac{\hat{B}_{it}^{K} \times \rho_t}{p_t^I}, \tag{A-2}$$

where $\hat{X}_{it}^{K}$ denotes real tangible assets for firm i in year t (2000 constant prices); ρ_t is the conversion rate;[19] and p_t^I is the investment goods deflator. The real value of tangible assets in the initial year τ (τ is 1994 or the first year when a firm appeared in the *BSJBSA*) is defined as the initial capital stock: $\hat{X}_{i\tau}^{K}$. Then the perpetual inventory method is used to

[18] Therefore, the land ratio is constant throughout the period.

[19] For more details about the conversion rate, see Tokui, Inui, and Kim (2008).

construct real capital stock:

$$X_{it}^K = X_{it-1}^K (1 - \delta_t) + X_{it}^I / p_t^I, \tag{A-3}$$

where X_{it}^K is the capital stock for firm i in year t; δ_t is the depreciation rate; X_{it}^I is investment; and p_t^I is the investment goods deflator.[20] The depreciation rate is defined as the weighted average of various assets in an industry. The investment goods deflator is defined as sectoral nominal investment flows divided by sectoral real investment flows. Both the depreciation rate and the investment goods deflator are obtained from the JIP 2009 database.

The cost of intermediate inputs is defined as nominal intermediate inputs while that of labor is wage payments. The cost of capital is the user cost of capital multiplied by the real capital stock. The user cost of capital is obtained from the JIP 2009 database and defined as the sectoral nominal capital cost divided by the sectoral real capital stock.

Exports are also available at the firm level in the *BSJBSA*. One problem is that the definition of exports in the *BSJBSA* changed in 1997. Before 1997, exports included sales by foreign branches (indirect exports). After 1997, however, exports are defined as exports from the parent firm (direct exports). Total (direct plus indirect) exports are also available between 1997 and 1999. For consistency, this paper focuses on direct exports. Exports before 1997 are adjusted by multiplying the figure by the ratio of direct exports to total exports. The ratio of direct exports is defined as the industry-average ratio of direct exports to total exports between 1997 and 1999.

Note that the industry classification of the *BSJBSA* is not the same as that of the JIP 2009 database. If one industry in the *BSJBSA* corresponds to more than one industry in the JIP 2009 database, we aggregate the nominal values and real values from the JIP

[20] We regard firms that did not report investment as firms with no investment (zero investment).

2009 database and then divide the aggregate nominal values by the aggregate real values to obtain indices. The concordance of the industry classification between the *BSJBSA* and the JIP 2009 database is presented in Table A1.

In constructing these variables, some firms report unusual figures. This paper 1) selects manufacturing; 2) removes firms whose sales and inputs were not positive; 3) removes firms whose changes in output Δy_{it} and inputs Δx_{it}^V and Δx_{it}^K exceed mean$\pm 4\sigma$, where σ is the standard deviation of the corresponding variable; and 4) removes reentry firms that disappear once and reappear, because it is difficult to construct the capital stock in a consistent way. As Table A2 shows, the total number of observations exceeds 8,000 annually.

References

Arellano, Manuel and Stephen Bond (1991) "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations," *Review of Economic Studies*, 58(2): 277–297.

Baltagi, Badi H. (2005) *Econometric Analysis of Panel Data*, 3rd Ed., Chichester, UK: John Wiley & Sons.

Bank of Japan (BOJ) (2010) *TANKAN* (*The Short-Term Survey of Enterprises in Japan*), Tokyo: BOJ website.

Basu, Susanto (1996) "Procyclical Productivity: Increasing Returns to Scale or Cyclical Utilization," *Quarterly Journal of Economics*, 111(3): 719–751.

Basu, Susanto and John G. Fernald (1997) "Returns to Scale in U.S. Production: Estimates and Implications," *Journal of Political Economy*, 105(2): 249–283.

Basu, Susanto and John G. Fernald (2001) "Why Is Productivity Procyclical? Why Do

We Care?" in Charles R. Hulten, Edwin R. Dean, and Michael J. Harper (eds.), *New Developments in Productivity Analysis*, Chicago, IL: University of Chicago Press/NBER, 225–301.

Beccarello, Massimo (1996) "Time Series Analysis of Market Power: Evidence from G-7 Manufacturing," *International Journal of Industrial Organization*, 15(1): 123–136.

Blundell, Richard and Stephen Bond (1998) "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models," *Journal of Econometrics*, 87(1): 115–143.

Bottasso, Anna and Alessandro Sembenelli (2001) "Market Power, Productivity and the EU Single Market Program: Evidence from a Panel of Intalian Firms," *European Economic Review*, 45(1): 167–186.

Chevalier, Judith A. and David S. Scharfstein (1996) "Capital-Market Imperfections and Countercyclical Markups: Theory and Evidence," *American Economic Review*, 86(4): 703–725.

Domar, Evsey D. (1961) "On the Measurement of Technical Change," *Economic Journal*, 71(284): 710–729.

Fukao, Kyoji, Sumio Hamagata, Tomohiko Inui, Keiko Ito, Hyeog Ug Kwon, Tatsuji Makino, Tsutomu Miyagawa, Yasuo Nakanishi, and Joji Tokui (2007) "Estimation Procedures and TFP Analysis of the JIP Database 2006," RIETI Discussion Paper, 07-E-003.

Fukao, Kyoji and Hyeog Ug Kwon (2006) "Why Did Japan's TFP Growth Slow Down in the Lost Decade? An Empirical Analysis Based on Firm-Level Data of Manufacturing," *Japanese Economic Review*, 57(2): 195–228.

Good, David H., M. Ishaq Nadiri, and Robin Sickles (1997) "Index Number and Factor Demand Approaches to the Estimation of Productivity," in M. Hashem Pesaran and

Peter Schmidt (eds.), *Handbook of Applied Econometrics: Microeconometrics*, Vol. II., Oxford: Blackwell.

Hayashi, Fumio and Edward C. Prescott (2002) "The 1990s in Japan: A Lost Decade," *Review of Economic Dynamics*, 5(1): 206–235.

Inklaar, Robert (2007) "Cyclical Productivity in Europe and the United States: Evaluating the Evidence on Returns to Scale and Input Utilization," *Economica*, 74(296): 822–841.

Kawamoto, Takuji (2005) "What Do the Purified Solow Residuals Tell Us about Japan's Lost Decade?" *Monetary and Economic Studies*, 23(1): 113–148.

Kiyota, Kozo, Takanobu Nakajima, and Kiyohiko G. Nishimura (2009) "Measurement of the Market Power of Firms: The Japanese Case in the 1990s," *Industrial and Corporate Change*, 18(3): 381–414.

Klette, Tor Jacob (1999) "Market Power, Scale Economies and Productivity: Estimates from a Panel of Establishment Data," *Journal of Industrial Economics*, 47(4): 451–476.

Miyagawa, Tsutomu, Yukie Sakuragawa, and Miho Takizawa (2006) "Productivity and Business Cycles in Japan: Evidence from Japanese Industry Data," *Japanese Economic Review*, 57(2): 161–186.

Nishimura, Kiyohiko G., Takanobu Nakajima, and Kozo Kiyota (2005) "Does the Natural Selection Mechanism Still Work in Severe Recessions? Examination of the Japanese Economy in the 1990s," *Journal of Economic Behavior and Organization*, 58(1): 53–78.

Nishimura, Kiyohiko G., Yasushi Ohkusa, and Kenn Ariga (1999) "Estimating the Mark-up Over Marginal Cost: A Panel Analysis of Japanese Firms 1971–1994," *International Journal of Industrial Organization*, 17(8): 1077–1111.

Research and Statistics Department, Ministry of Economy, Trade and Industry (METI) (1994–2006) *Kigyou Katsudou Kihon Chousa Houkokusho* (*Basic Survey of Japanese Business Structure and Activities*), Tokyo: METI.

Research and Statistics Department, Ministry of Economy, Trade and Industry (METI) (2010) *Kokogyou Seisan Shisuu* (*Indices on Mining and Manufacturing*), Tokyo: METI website.

Rotemberg, Julio J. and Michael Woodford (1991) "Markups and the Business Cycle," *NBER Macroeconomics Annual 1991*, 6: 63–129.

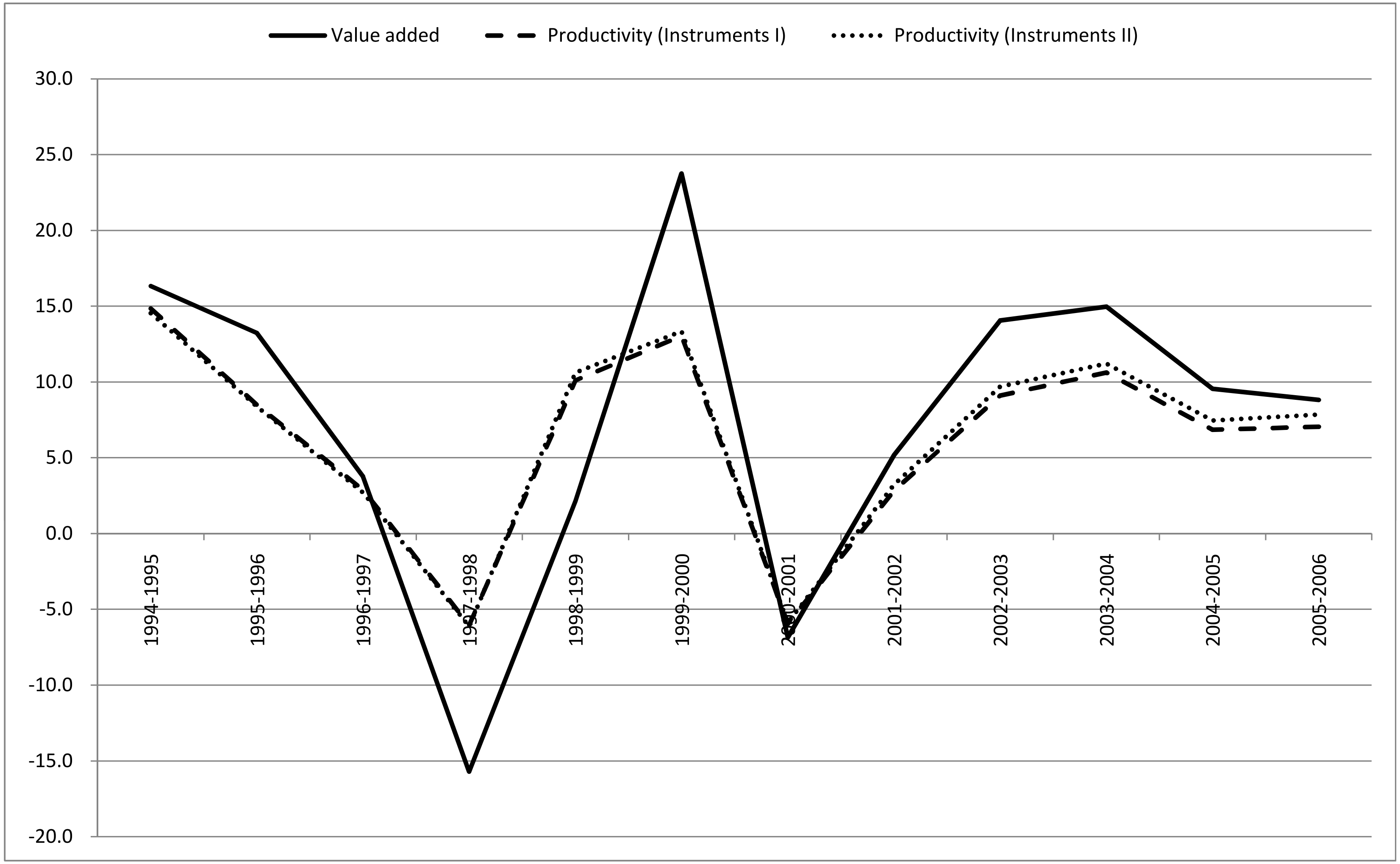
Tokui, Joji, Tomohiko Inui, and Young Gak Kim (2008) "Embodied Technological Progress and Productivity Slowdown in Japan," RIETI Discussion Paper Series 08-E-017, Research Institute of Economy, Trade, and Industry.

Van Biesebroeck, Johannes (2007) "Robustness of Productivity Estimates," *Journal of Industrial Economics*, 55(3): 529–569.

Wooldridge, Jeffrey M. (2002) *Econometric Analysis of Cross Section and Panel Data*, Cambridge, MA: MIT Press.

Figure 1. Is Aggregate Productivity Pro-cyclical?

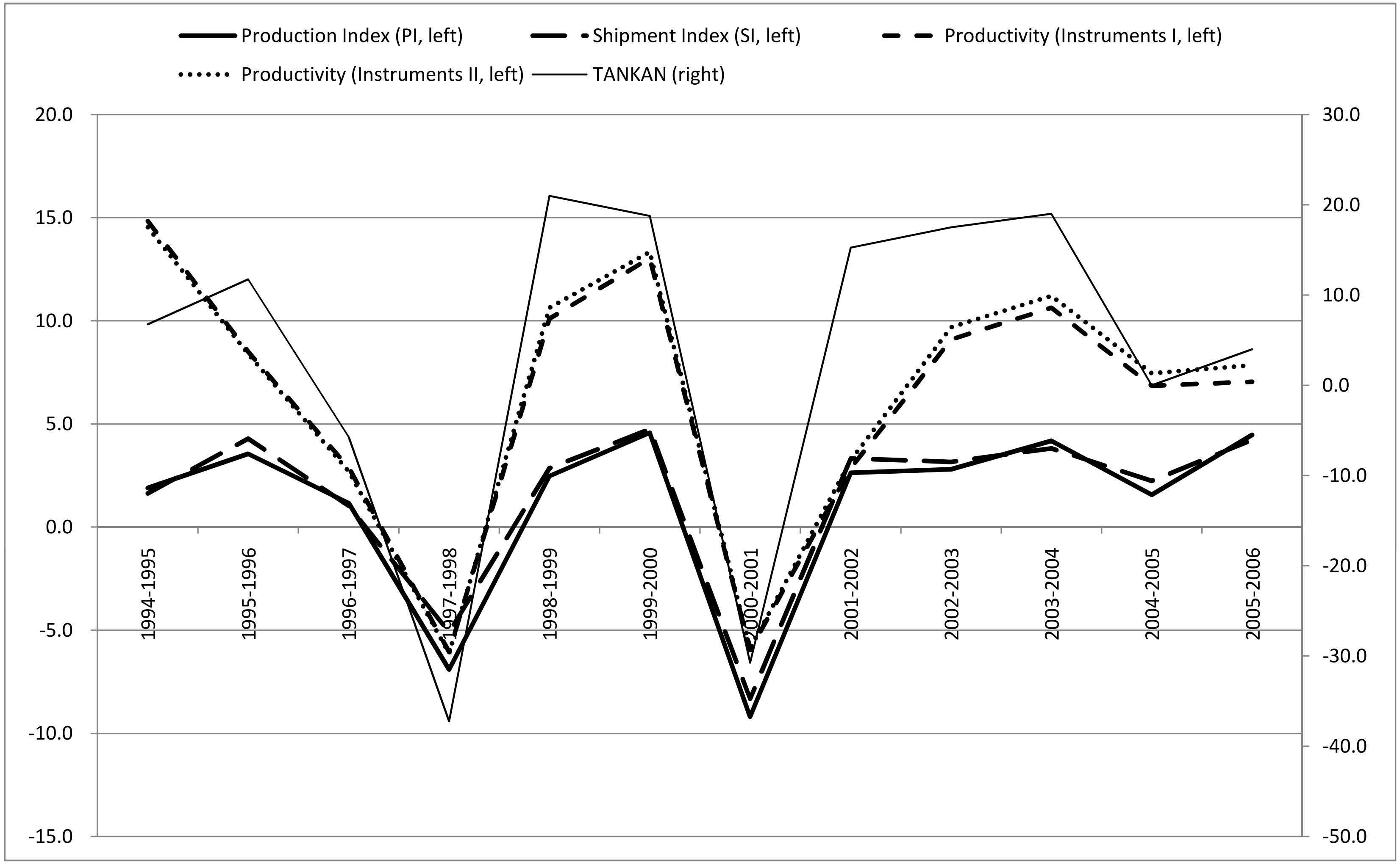
(Percent)



Note: Value added indicates the growth of real value added. "Productivity (Instruments I)" and "Productivity (Instruments II)" are the estimated productivity growth from Instruments I and II, respectively. Vertical axis indicates the growth rate (percent).
Source: METI (1995-2006)

Figure 2. Aggregate Productivity and the Business Cycle: Alternative Measures of the Business Cycle

(Percent for production, shipments, and productivities (left) and difference for TANKAN (right))



Note: The TANKAN is obtained from Bank of Japan (2010). The PI and SI indicate Composite and Diffusion Indices that are obtained from METI (2010). "Productivity (Instruments I)" and "Productivity (Instruments II)" are the estimated productivity growth from Instruments I and II, respectively. Vertical axis indicates the growth rate (percent) for production, shipments, and productivity (left) and the difference for TANKAN

Source: BOJ (2010), METI (1995-2006), and METI (2010)

Table 1. Changes in Output (Real Value Added), by Industry

(Percent)

	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	1994-2006
Manufacturing	**16.3**	**13.2**	**3.7**	**-15.7**	**2.1**	**23.7**	**-6.8**	**5.2**	**14.1**	**15.0**	**9.5**	**8.8**	**7.0**
Livestock, seafood, and flour products	13.3	5.4	-14.1	4.2	-6.9	-14.2	6.9	8.6	-1.7	5.9	-0.3	-2.7	0.4
Miscellaneous food and related products	6.6	14.7	-6.4	4.5	-4.2	-4.5	2.5	-3.9	6.4	2.1	0.9	1.8	1.7
Beverages and tobacco	0.6	15.7	-3.8	-14.6	-15.0	-13.2	-5.4	-10.1	4.3	10.6	4.8	9.2	-1.4
Textiles	-1.9	10.9	-1.9	-22.7	-4.3	-4.0	-10.5	-4.3	1.9	-3.0	6.2	-12.5	-3.8
Clothing	-0.4	14.6	-13.7	-20.6	-17.2	-2.8	-9.3	-0.1	1.9	-2.7	-0.9	-0.2	-4.2
Woods, paper, and pulp	20.2	1.3	-2.3	-16.4	4.9	7.5	-16.9	-7.3	2.3	1.1	7.6	0.2	0.2
Chemicals	23.8	63.9	7.9	-56.6	-17.8	81.3	-9.1	-13.8	6.7	19.5	18.6	8.6	10.0
Organic chemical products	22.6	21.2	4.8	-0.2	10.3	-8.8	-4.2	1.2	-16.0	-0.1	4.6	-2.7	2.7
Miscellaneous chemical products	7.1	21.5	3.4	-4.2	6.3	6.8	-4.5	5.3	7.6	6.8	1.7	2.1	4.8
Plastics	13.7	16.9	-0.3	-1.4	-3.3	9.4	-12.3	4.1	8.3	7.1	4.8	-4.3	3.5
Ceramic, stone, and clay products	10.6	10.1	-5.4	-15.2	0.7	21.8	-17.6	0.7	13.4	3.4	6.4	-2.9	2.2
Steel	7.2	4.5	-4.6	-30.5	2.4	8.3	-20.3	9.3	-1.4	-0.8	-12.8	4.8	-2.8
Metals	23.6	13.6	-1.4	-6.7	-4.7	19.8	-22.4	-12.4	1.0	24.1	26.8	4.4	5.3
Architectural metal products	17.9	10.1	-3.1	12.1	11.1	-18.1	-16.2	-7.7	-11.0	-26.3	4.4	12.6	-1.2
Other metal products	11.6	3.1	-2.0	-19.6	-4.3	24.9	-12.1	-1.6	2.9	6.7	4.5	-0.7	1.1
Special industrial machinery	34.0	5.3	-13.9	-34.8	-5.5	55.3	-28.8	0.4	16.7	18.7	7.7	20.4	6.1
General industrial machinery	38.6	16.5	7.2	-10.6	12.2	32.2	-10.3	-7.8	20.2	25.0	16.4	9.8	10.6
Miscellaneous machinery	2.8	-4.5	-7.4	-23.0	-8.5	18.5	-4.5	8.1	2.1	0.0	12.9	-0.0	-0.3
Industrial apparatus	13.8	-2.1	-4.2	-13.5	-2.5	15.0	-29.5	-4.0	-7.4	13.2	11.2	14.4	0.4
Household electric appliances	36.6	1.6	16.5	2.0	22.2	7.9	-20.5	21.3	55.5	34.7	11.2	38.3	13.6
Other electrical machinery	92.0	35.3	34.8	-1.7	-11.1	67.8	7.6	25.9	41.6	27.0	-2.3	17.5	15.7
Electronic parts and components	92.5	26.7	42.9	-24.7	36.0	43.6	-18.1	20.7	24.8	27.0	32.0	7.5	15.4
Motor vehicles	7.6	3.5	2.8	-14.9	12.2	12.6	2.2	-0.4	1.6	2.6	17.4	2.2	4.0
Other transportation equipment	23.3	-1.2	-17.8	-10.7	-5.8	25.2	-0.4	-3.2	3.3	30.6	8.1	1.3	4.3
Precision instruments	13.8	17.1	1.3	-4.2	1.1	10.6	-19.5	9.4	15.8	5.6	3.4	8.1	5.0
Micellaneous manufacturing products	-12.1	-5.9	43.4	-17.5	22.3	4.2	-8.8	11.4	2.9	4.0	11.8	28.1	6.7

Source: METI (1995-2006)

Table 2. Estimation Results: Summary and Test Statistics

		Instruments I					Instruments II				
	N	Period-average markup	Period-average scale	Hansen test statistic	AR(1)	AR(2)	Period-average markup	Period-average scale	Hansen test statistic	AR(1)	AR(2)
Livestock, seafood, and flour products	4,091	0.964	0.918	139.7	-9.499*	2.950*	0.970	0.932	312.1	-9.525*	2.971*
Miscellaneous food and related products	7,221	0.883	0.832	153.1	-12.310*	2.427	0.900	0.867	338.0	-12.280*	2.480
Beverages and tobacco	1,488	0.959	0.899	122.7	-6.657*	1.833	0.969	0.916	116.0	-6.686*	1.825
Textiles	2,982	0.933	0.874	148.8	-8.605*	0.739	0.942	0.909	239.8	-8.637*	0.818
Clothing	2,923	0.825	0.782	151.6	-7.749*	1.363	0.836	0.816	265.0	-7.673*	1.503
Woods, paper, and pulp	6,180	0.926	0.866	189.4*	-6.563*	2.083	0.942	0.902	356.9*	-6.380*	2.113
Chemicals	4,701	0.898	0.807	148.1	-8.934*	0.572	0.921	0.855	302.5	-8.859*	0.676
Organic chemical products	1,714	0.940	0.884	145.5	-5.600*	-0.174	0.956	0.927	140.3	-5.461*	-0.124
Miscellaneous chemical products	3,402	0.942	0.861	132.2	-9.833*	-0.146	0.955	0.892	264.7	-9.824*	-0.092
Plastics	5,611	0.958	0.896	143.7	-8.857*	3.130*	0.971	0.925	321.8	-8.768*	3.167*
Ceramic, stone, and clay products	4,790	0.949	0.850	130.2	-10.430*	-0.098	0.963	0.897	304.7	-10.260*	0.061
Steel	3,549	1.104	1.012	164.9	-9.776*	0.366	1.105	1.019	299.5	-9.671*	0.417
Metals	2,670	0.993	0.935	150.8	-6.013*	1.422	0.995	0.938	251.2	-6.066*	1.399
Architectural metal products	2,713	0.991	0.937	147.9	-7.629*	2.253	0.999	0.978	260.0	-7.532*	2.342
Other metal products	5,548	0.892	0.826	138.6	-9.102*	2.273	0.908	0.866	297.3	-8.686*	2.640*
Special industrial machinery	3,299	1.037	0.956	145.0	-7.580*	2.086	1.042	0.979	278.7	-7.590*	2.142
General industrial machinery	3,361	0.987	0.915	157.8	-9.320*	-0.476	0.988	0.922	279.1	-9.241*	-0.415
Miscellaneous machinery	6,267	1.013	0.931	173.3	-13.050*	2.571	1.024	0.959	316.1	-13.020*	2.669*
Industrial apparatus	3,382	0.993	0.893	152.2	-8.248*	2.670*	1.001	0.924	274.3	-8.228*	2.748*
Household electric appliances	1,076	1.013	0.926	90.9	-3.311*	0.586	1.016	0.959	93.0	-3.364*	0.613
Other electrical machinery	5,534	0.951	0.918	198.7*	-11.350*	1.269	0.955	0.928	316.9	-11.340*	1.316
Electronic parts and components	5,975	0.996	0.949	171.8	-11.000*	1.411	0.996	0.960	312.6	-10.990*	1.429
Motor vehicles	7,705	0.961	0.926	149.9	-7.959*	2.257	0.967	0.947	280.0	-7.862*	2.284
Other transportation equipment	1,803	0.956	0.957	151.3	-8.103*	0.677	0.961	0.971	143.2	-8.104*	0.671
Precision instruments	2,734	0.941	0.897	154.4	-8.019*	0.803	0.950	0.923	265.7	-8.047*	0.935
Micellaneous manufacturing products	2,294	1.005	0.917	125.7	-6.265*	-1.162	1.009	0.931	246.7	-6.260*	-1.155

Note: Coefficients are estimated by one-step system GMM. Period-average markup and scale are the period-average of the estimated coefficients of markup and scale, respectively. The null hypothesis of the Hansen test is that the instruments are exogenous. * indicates level of significance at 1%. For instruments, see main text.

Source: METI (1995-2006)

Table 3. Are Productivity, Markup, and Scale Economies Constant?

	Instruments I					Instruments II				
	H_0: coefficients = no change			H_0: coefficients = 1		H_0: coefficients = no change			H_0: coefficients = 1	
	Productivity	Markup	Scale	Markup	Scale	Productivity	Markup	Scale	Markup	Scale
Livestock, seafood, and flour products	251.7***	13.7	20.1*	39.9***	63.1***	341.6***	18.0	14.9	24.5**	51.3***
Miscellaneous food and related products	466.5***	14.3	41.8***	80.0***	135.2***	335.2***	25.0**	28.3***	77.9***	141.2***
Beverages and tobacco	282.3***	18.0	14.8	17.5	20.8*	414.2***	32.6***	19.6*	21.4**	42.0***
Textiles	615.8***	26.4***	8.7	100.1***	87.0***	185.0***	20.3*	11.2	35.2***	60.6***
Clothing	298.4***	30.8***	25.5**	97.0***	116.8***	76.5***	35.7***	26.6***	62.5***	83.8***
Woods, paper, and pulp	262.8***	77.6***	47.6***	41.2***	64.5***	228.6***	45.9***	32.4***	39.6***	61.6***
Chemicals	360.1***	69.5***	44.9***	41.3***	76.3***	1,155.1***	39.4***	57.5***	23.5**	66.9***
Organic chemical products	189.7***	34.6***	37.7***	33.9***	44.2***	278.7***	24.8**	23.9**	54.2***	34.8***
Miscellaneous chemical products	515.2***	11.5	8.6	17.5	47.7***	660.5***	14.9	14.1	8.9	56.2***
Plastics	490.7***	25.2**	13.2	21.4**	31.7***	394.7***	17.3	12.4	9.9	35.8***
Ceramic, stone, and clay products	184.9***	27.9***	14.6	112.7***	134.8***	248.3***	16.3	31.2***	19.2*	46.8***
Steel	630.3***	27.6***	43.5***	60.2***	10.3	252.2***	26.5***	22.6**	141.4***	18.2
Metals	273.3***	21.9**	30.6***	34.2***	19.4*	208.7***	17.4	27.7***	28.8***	30.3***
Architectural metal products	661.0***	16.3	17.3	43.6***	27.8***	297.5***	8.8	20.2*	37.1***	42.9***
Other metal products	388.8***	15.2	20.0*	38.7***	48.9***	712.3***	10.9	17.8	19.0*	32.3***
Special industrial machinery	676.0***	22.0**	14.7	36.1***	27.0***	568.0***	35.9***	12.8	40.7***	22.8**
General industrial machinery	377.6***	36.4***	34.9***	51.3***	27.2***	287.5***	18.7*	21.3**	38.8***	29.4***
Miscellaneous machinery	471.5***	24.1**	17.8	89.7***	31.9***	461.9***	11.6	23.6**	38.2***	26.4***
Industrial apparatus	440.9***	16.6	6.9	80.3***	22.4**	211.1***	18.7*	12.2	28.3***	27.0***
Household electric appliances	178.0***	23.9**	5.7	16.2	12.5	334.6***	17.0	15.1	25.4**	11.8
Other electrical machinery	413.1***	29.3***	30.0***	49.5***	56.3***	1,191.5***	18.1	21.9**	90.5***	47.4***
Electronic parts and components	767.9***	52.6***	27.6***	29.7***	66.3***	2,309.3***	13.2	15.9	9.1	25.0**
Motor vehicles	536.8***	32.6***	33.4***	38.9***	28.4***	689.9***	22.0**	31.0***	43.7***	27.0***
Other transportation equipment	427.1***	20.0*	24.5**	58.1***	38.7***	335.7***	19.9*	19.1*	17.0	18.4
Precision instruments	113.0***	18.3	17.7	24.3**	26.6***	195.5***	12.2	13.3	14.3	35.4***
Micellaneous manufacturing products	367.2***	23.9**	36.0***	11.8	6.5	224.0***	19.1*	17.8	18.9*	20.4*

Note: Figure reports chi-squared test statistics. ***, **, and * indicate level of significance at 1%, 5%, and 10%, respectively.
Source: METI (1995-2006)

Table 4. Do Sectoral Productivity, Markup, and Scale Economies Correlate with the Business Cycle?

	Instruments I						Instruments II					
	Productivity		Markup		Scale economies		Productivity		Markup		Scale economies	
Growth of value added	0.098***	0.109***	-0.001	0.000	0.002	0.001	0.098***	0.108***	0.000	0.001	0.002	0.002
	[0.005]	[0.005]	[0.003]	[0.003]	[0.001]	[0.001]	[0.005]	[0.005]	[0.003]	[0.003]	[0.001]	[0.001]
Changes in HHI	-0.379***	-0.328***	-0.004	0.005	0.029	0.042	-0.373***	-0.312**	-0.002	0.005	0.032	0.042
	[0.128]	[0.123]	[0.080]	[0.076]	[0.038]	[0.036]	[0.127]	[0.123]	[0.080]	[0.075]	[0.037]	[0.035]
Growth of exports	-0.002	-0.005	0.000	0.000	0.000	0.000	-0.003	-0.005	-0.001	0.000	0.000	0.000
	[0.004]	[0.004]	[0.002]	[0.002]	[0.001]	[0.001]	[0.004]	[0.004]	[0.002]	[0.002]	[0.001]	[0.001]
Observations	312	312	312	312	312	312	312	312	312	312	312	312
Number of industries	26	26	26	26	26	26	26	26	26	26	26	26
R-squared												
Within	0.580	0.579	0.001	0.000	0.008	0.007	0.579	0.578	0.001	0.000	0.011	0.010
Between	0.932	0.936	0.068	0.028	0.014	0.046	0.929	0.933	0.187	0.023	0.018	0.035
Overall	0.650	0.651	0.000	0.000	0.008	0.009	0.649	0.650	0.000	0.000	0.011	0.012
Effects	Fixed	Random	Fixed	Random	Fixed	Random	Fixed	Random	Fixed	Random	Fixed	Random
Robust Hausman test	6.94***		3.87**		2.52*		6.79***		4.46**		2.64*	

	Instruments I						Instruments II					
	Productivity		Markup		Scale economies		Productivity		Markup		Scale economies	
Growth of value added	0.098***	0.108***	-0.001	0.000	0.002	0.001	0.097***	0.107***	-0.001	0.001	0.002	0.002
	[0.005]	[0.005]	[0.003]	[0.003]	[0.001]	[0.001]	[0.005]	[0.004]	[0.003]	[0.003]	[0.001]	[0.001]
Changes in HHI	-0.367***	-0.320***	-0.001	0.008	0.028	0.041	-0.362***	-0.304**	0.001	0.008	0.032	0.041
	[0.127]	[0.123]	[0.080]	[0.076]	[0.038]	[0.036]	[0.126]	[0.123]	[0.080]	[0.075]	[0.037]	[0.035]
Changes in export-output ratio	-0.095**	-0.065*	-0.022	-0.024	0.009	0.007	-0.099**	-0.071*	-0.025	-0.026	0.005	0.004
	[0.041]	[0.040]	[0.026]	[0.024]	[0.012]	[0.011]	[0.041]	[0.039]	[0.026]	[0.024]	[0.012]	[0.011]
Observations	312	312	312	312	312	312	312	312	312	312	312	312
Number of industries	26	26	26	26	26	26	26	26	26	26	26	26
R-squared												
Within	0.587	0.585	0.003	0.002	0.010	0.009	0.587	0.585	0.003	0.003	0.011	0.010
Between	0.926	0.931	0.001	0.015	0.011	0.025	0.923	0.929	0.000	0.039	0.028	0.039
Overall	0.650	0.652	0.002	0.003	0.009	0.010	0.649	0.651	0.003	0.004	0.012	0.012
Effects	Fixed	Random	Fixed	Random	Fixed	Random	Fixed	Random	Fixed	Random	Fixed	Random
Robust Hausman test	6.39***		1.63		0.61		6.52***		1.89		0.44	

Note: ***, **, and * indicate level of significance at 1%, 5%, and 10%, respectively. Figures in brackets indicate standard errors. HHI stands for Herfindahl--Hirschman Index. Robust Hausman test reports the Wald test statitics, based on cluster--robust standard errors (Wooldridge, 2002). The null hypothesis is that the random effect estimator is consistent.

Source: METI (1995-2006)

Table A1. Industry Classification

	BSJBSA	JIP 2009 Database
Livestock, seafood, and flour products	91	8
	92	9
	93	10
Miscellaneous food and related products	99	11
	102	12
Beverages and tobacco	101	13, 14
Textiles	111, 112, 113, 119	15
Clothing	121, 122	15
Woods, paper, and pulp	131, 139	16
	140	17
	151	18
	152	19
Chemicals	171	23, 24
	175	29
	201, 209	22
	181	30
	189	30, 31
Organic chemical products	172	25, 26
	173	27
Miscellaneous chemical products	174, 179	28
Plastics	190	58
Ceramic, stone, and clay products	221	32
	222	33
	229	35
Steel	231	36
	232	37
Metals	241	38
	242	39
Architectural metal products	251	40
Other metal products	259	41
Special industrial machinery	262	43
General industrial machinery	261	42
	263	45
Miscellaneous machinery	269	44
Industrial apparatus	271	46
Household electric appliances	272	47
Other electrical machinery	273	50
	279	53
	281	49
	282	48
Electronic parts and components	290	51, 52
Motor vehicles	301	54, 55
Other transportation equipment	309	56
Precision instruments	311, 312, 313, 319	57
Micellaneous manufacturing products	210	21
	320	59

Note: Each figure corresponds to industry classification codes. BSJBSA classification is based on 2006 version.

Table A2. Number of Firms, by Industry

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Manufacturing	**8,557**	**8,435**	**9,099**	**9,136**	**9,082**	**8,936**	**8,660**	**8,481**	**8,371**	**8,256**	**8,282**	**8,262**	**8,013**
Livestock, seafood, and flour products	315	313	344	334	350	346	344	345	350	343	344	342	336
Miscellaneous food and related products	535	526	584	597	624	629	617	620	606	608	612	611	587
Beverages and tobacco	119	117	124	130	131	126	128	122	118	125	125	123	119
Textiles	317	312	309	306	284	274	248	237	222	210	201	199	180
Clothing	337	334	354	325	288	258	228	220	205	184	181	175	171
Woods, paper, and pulp	540	536	565	559	559	555	536	518	489	478	473	465	447
Chemicals	394	392	405	397	402	395	389	392	391	383	386	389	380
Organic chemical products	143	142	146	151	142	148	148	144	143	135	140	140	135
Miscellaneous chemical products	281	278	299	292	290	294	287	285	280	277	273	281	266
Plastics	423	419	470	476	480	479	473	471	470	474	469	480	450
Ceramic, stone, and clay products	452	445	475	462	458	431	406	386	370	347	348	333	329
Steel	303	300	314	316	301	295	289	283	290	283	288	300	290
Metals	230	227	234	232	230	232	222	222	219	216	218	211	207
Architectural metal products	250	249	266	266	248	231	229	223	209	204	201	206	181
Other metal products	437	429	458	475	481	488	480	468	459	460	457	454	439
Special industrial machinery	259	257	284	289	285	284	279	270	267	274	274	270	266
General industrial machinery	278	278	306	306	302	297	287	265	265	259	267	270	259
Miscellaneous machinery	495	488	522	527	537	536	533	520	515	527	520	524	518
Industrial apparatus	268	264	297	294	292	280	286	274	285	282	277	277	274
Household electric appliances	106	103	111	105	99	92	81	79	81	82	81	79	83
Other electrical machinery	455	440	481	499	506	497	457	454	453	434	437	439	437
Electronic parts and components	459	445	500	523	531	532	504	487	488	484	501	495	485
Motor vehicles	603	592	668	678	667	659	650	639	636	627	642	627	620
Other transportation equipment	147	146	149	163	161	148	143	147	145	147	152	152	150
Precision instruments	210	207	227	226	227	233	229	226	234	234	237	230	224
Micellaneous manufacturing products	201	196	207	208	207	197	187	184	181	179	178	190	180

Source: METI (1995-2006)